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## SEAT OCCUPANCY SENSOR

### *Introduction*

The invention concerns a seat occupancy sensor, especially for use in  
5 recognition of seat occupancy in a motor vehicle.

Seat occupancy sensors have been used for some time in motor vehicles for  
purposes of airbag control. By means of these seat occupancy sensors, the  
state of occupancy of a motor vehicle seat is determined, and the airbag  
10 allocated to a given seat is only activated if the current state of occupancy of  
the seat warrants such activation. These seat occupancy sensors in general  
present a plurality of switch elements, for example pressure sensors, in an  
arrangement distributed in the sitting surface of the motor vehicle seat. An  
evaluating processor unit connected to the seat occupancy sensor queries the  
15 circuit status of each individual switch element, and from the circuit status of  
each of the seat occupancy sensors, determines the occupancy state of the  
seat. If the seat is occupied by a person, several of the switch elements will be  
activated by the force exerted on them by the weight of the person, and a state  
of occupancy of the seat will be recognized by the connected evaluating  
20 processor unit and will be relayed to the airbag control.

In principle, if the circuit status of the individual switch elements is to be  
queried, each of the switch elements must be connected to the evaluating  
processor unit. To reduce the number of connecting conductors required for  
25 this purpose, the individual switch elements are usually operated in a matrix  
circuit. This means that where there is a number  $n*m$  of switch elements,  
essentially  $n$  row conductors and  $m$  column conductors are provided, each of  
the switch elements being included in the circuit between one row conductor  
and one column conductor. It should be noted in this connection that such a  
30 matrix circuit represents a technical designation of the circuit layout. This

means that the switch elements in a matrix circuit do not need to be really distributed in a regular grid arrangement, nor need the individual connection conductors be straight and parallel or at right angles to each other.

- 5 For evaluation of a sensor array in a matrix circuit, the procedure is as follows: first, the entire matrix circuit, with the exception of a first column conductor, is put on the same voltage, for example earth. A test voltage is now applied to the first column conductor, and current flowing in the individual row conductors is then selectively measured. In this way, the circuit status existing between the
- 10 first column conductor and the different row conductors can be selectively determined. If this procedure is repeated for each of the column conductors, all the switch elements can be selectively evaluated in sequence.

- With the seat occupancy sensor described, the occupancy situation of a seat
- 15 can be determined with great precision for different zones of the motor vehicle seat, with a relatively accurate classification through the distribution of the occupancy. Such a precise classification is necessary for applications relating to safety, such as the control of the airbag allocated to the seat, in order to avoid unwanted activation of the safety system. Nevertheless, the system for
- 20 occupancy recognition described above is relatively costly, both as regards the circuitry of the individual switch elements and the construction of the evaluating processor unit.

- For applications not critical to safety, for which an exact assessment of seat
- 25 occupancy is not essential, it is desirable to provide a less costly seat occupancy sensor. One example of such an application is the seat belt warning system that reminds a passenger taking his place in the passenger seat to fasten his seat belt. A warning system of this kind may emit an audio or visible signal, if the motor vehicle seat is occupied but the fastening of the
- 30 corresponding seat belt has not been done up. The seat occupancy sensor in a system like this must basically be capable of distinguishing between seat occupancy by a passenger and occupancy by some object, such as a handbag.

For this application, a more costly classification of seat occupancy is not needed.

### **The task of the invention**

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It was the task of this invention to propose an especially simple seat occupancy sensor that would be suitable for applications not critical for safety.

### **General description of the invention**

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This task is fulfilled according to the invention by a seat occupancy sensor according to Claim 1. This seat occupancy sensor comprises at least two switch elements actuatable by pressure that can be arranged with a certain distance between them in a surface of a seat so that a first switch element is  
15 allocated to a first area of the seat and a second switch element is allocated to a second area of the seat. According to the invention, the first and second switch elements are connected together in such a way as to form a logical AND gate. In a specially simple embodiment of the invention, the first and second switch elements are connected together, in series, for example.

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The effect of connecting a minimum of two switch elements in the form of an AND gate is that a signal from the two elements can only be measured when both switch elements are actuated by a corresponding occupancy of the seat. Accordingly, with the proposed seat occupancy sensor, at least two switch  
25 elements, which are arranged in different parts of the motor vehicle seat when the sensor is installed, are connected in a circuit in such a way that occupancy of the seat is only detected as such if both switch elements are actuated by occupancy simultaneously. By this means, seat occupancy that is relevant to the seat belt warning system will only be recognized as such if the occupancy  
30 of the motor vehicle seat extends over a predetermined distance. Local actuation of the seat occupancy sensor, for example due to the presence of an object such as a handbag placed on the seat, will not be recognized as seat occupancy and the seat belt warning system will consequently not respond.

The connection in a circuit according to the invention of at least two switch elements arranged with some distance between them thus enables particularly simple detection of seat occupancy, capable of distinguishing between local  
5 and wide-area occupancy of the seat without the need for a costly matrix circuit and a costly evaluating processor unit.

It should be noted that the seat occupancy sensor may be provided with more than two switch elements. Thus three or more switch elements may be  
10 connected together to form a logical AND gate. Alternatively, several groups, each comprising two or more switch elements, may be provided.

In a particularly simple embodiment, the switch elements may take the form of simple switches, such as membrane switches, for example. In an  
15 advantageous embodiment of the invention, the first and/or second switch element comprises a pressure sensor. In this embodiment, in addition to detection of occupancy, information about the intensity of the pressure exerted can also be obtained, enabling more precise classification of the seat occupancy detected.

20 In a preferred embodiment of the invention, the first and/or second switch element comprises a plurality of individual switching cells, connected together in such a way that they form a logical OR gate. The individual switching cells of a switch element may be connected in parallel, for example. The effect of  
25 connecting the individual switching cells in an OR gate is that the switch element is actuated as soon as a single switching cell is actuated by a pressure load. If the individual switching cells are arranged in a cluster over a particular zone of the motor vehicle seat, this zone will constitute the active area of the corresponding switch element. Occupancy of any place within this zone will  
30 thus be recognized as occupancy of the switch element. Such a configuration of the switch elements with several individual switching cells enables the extent of the zone wherein seat occupancy can be recognized to be spatially defined.

In one possible embodiment of the seat occupancy sensor, the individual sensor cells of a switch element are arranged, for example, in a row, one behind the other. In this way, each of the switch elements presents a strip-shaped active area. The switch elements can then be arranged on or in the motor vehicle seat in such a way that the strip shaped active areas extend from a front edge to a back edge of the seat at a specific lateral distance from each other. Occupancy of the seat by a passenger, that is to say occupancy of the seat of sufficient lateral extent, can then be recognized independently of the sitting position adopted by the passenger in the longitudinal dimension of the seat. In this way, occupancy of the seat can be recognized by the pressure exerted by the bulge of the passenger's haunches irrespective of the actual size of the passenger and the individual distance between the two haunches.

In a particularly advantageous embodiment of the invention, the two switch elements are arranged at least approximately at the same distance from a line down the centre of the seat in the direction of travel of the vehicle and with a specific distance between them. By means of this symmetrical arrangement of the switch elements in relation to the centreline of the seat, occupancy of the seat that is significant for the belt warning system is only recognized as such if the occupancy of the motor vehicle seat extends over a predetermined distance and if the occupancy is at least approximately symmetrical with respect to the central plane of the seat. Localized actuation of the seat occupancy sensor, such as may result from the presence of an object such as a handbag placed on the seat, for example, will not be recognized as seat occupancy and in consequence the belt warning system will not respond.

Alternatively, the switch elements can be arranged in the seat in such a way that the first active area is positioned crossways in the front part of the seat and a second active area is positioned crossways in the rear part of the seat.

It should be noted that each individual switching cell preferably comprises a pressure sensor, so that information about the intensity of the pressure exerted

can also be obtained, enabling more precise classification of the seat occupancy detected.

As sensors for the embodiments of the inventions described above, foil-type pressure sensors are particularly suitable, and foil-type pressure sensors of different types can be employed, depending on requirements. For example, it is possible to employ foil-type pressure sensors that operate in what is called through-mode, or foil-type pressure sensors that operate in what is called shunt mode.

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With foil-type pressure sensors that operate in through-mode, a first contact element is located on a first supporting foil and a second contact element on a second supporting foil, the two supporting foils being with a certain distance between them and so arranged that the two contact elements are opposite each other. Between the two contact elements a layer of semiconductive material is provided which is pressed between the two contact elements when the sensor is actuated, so that the resistance between the two contact elements varies with the pressure exerted.

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Shunt mode foil-type pressure sensors present two contact elements arranged with a certain distance between them on a single supporting foil. On a second supporting foil a certain distance away, a semi-conductive layer is applied, arranged in such a way that it covers the area between the two contact elements and comes into contact with both contact elements when the supporting foils are pressed together.

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### ***Description of several embodiments with reference to figures***

An embodiment of the invention is described below with reference to figures.

These show the following:

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Fig. 1: Cross-section through an embodiment of the seat occupancy sensor;

Fig. 2: Cross-section through a sensor cell in shunt mode;

Fig. 3: Block diagram of an embodiment of a seat occupancy sensor;

Fig. 4: Block diagram of another embodiment of a seat occupancy sensor

A first embodiment of a seat occupancy sensor 10 is shown in cross-section in  
 5 Fig. 1. This is an embodiment using foil-type pressure sensors in what is called  
 "through-mode".

The seat occupancy sensor 10 shown comprises a first switch element 12 and  
 a second switch element 14, each comprising a plurality of individual sensor  
 10 cells 16.

Each sensor cell 16 comprises a first electrode 18 arranged on a first  
 supporting foil 20 and a second electrode 22 arranged on a second supporting  
 foil 24. The two supporting foils 20 and 24 are arranged by means of a spacer  
 15 28 provided with a recess 26 in such a way that the first electrode 18 and the  
 second electrode 22 of each sensor cell 16 are positioned opposite each other  
 and with a certain distance between them inside one of the recesses 26.

A layer 30 of some pressure-sensitive material, e.g. a suitable semi-conductive  
 20 material, is applied in each sensor cell 16 to one of the electrodes, as it might  
 be electrode 22, so that when the two supporting foils 20 and 24 are pressed  
 together, a pressure-dependent electrical contact is established between the  
 two electrodes through the pressure-sensitive layer 30.

25 It should be noted that all the sensor cells 16 present common supporting foils  
 20 and 24, on which the electrodes 18 and 22 are arranged, so that the seat  
 occupancy sensor constitutes a continuous mat.

The sensor cells 16 of a switch element 12 or 14 are connected together in  
 30 such a way that a logical OR gate is formed. This means that a particular  
 switch element produces an output signal corresponding to an actuation as  
 soon as at least one of the sensor cells is actuated. In the embodiment shown,  
 the logical OR gate is obtained by connecting the individual sensor cells 16 of

each switch element 12 or 14 in parallel. For this purpose, the first electrodes 18 of the sensor cells 16 in the switch elements 12 are connected together, for example, through a conductor track 32, while the second electrodes 22 of the sensor cells 16 in the switch elements 12 are connected together through a conductor track 34. Similarly, the first electrodes 18 of the sensor cells 16 in the switch elements 14 are connected together through a conductor track 36, while the second electrodes 22 of the sensor cells 16 in the switch elements 14 are connected together through a conductor track 38.

The two switch elements 12 and 14 themselves are connected together in such a way as to implement a logical AND gate. The effect of such a circuit is that an output signal from the seat occupancy sensor only appears at the outputs of the seat occupancy sensor if both the switch elements 12 and 14 are actuated by pressure exerted on them. In the embodiment shown, the logical AND gate is obtained by connecting the two switch elements 12 and 14 in series. For this purpose, the conductor track 34 is connected, for example, to the conductor track 38 by means of the jumper 40, while the output signal of the seat occupancy sensor is obtained between conductor tracks 32 and 36.

In an alternative embodiment of the seat occupancy sensor 10, the switch elements 12 or 14 may be composed of foil-type pressure sensors in shunt mode, as it is called. Fig. 2 shows a cross-section through a sensor cell 16 of this type. In this embodiment, the first electrode 18' and the second electrode 22' are mounted at a certain distance from each other on one of the supporting foils 24', while the pressure-sensitive layer 30' is applied to the other supporting foil 20'. The two supporting foils are arranged at a certain distance from each other by means of a spacer 28' provided with a recess 26' in such a way that the layer 30' and the two electrodes 18' and 22' are opposite each other and with a certain distance between them, so that when the two supporting foils 20' and 24' are pressed together, the pressure-sensitive layer 30' makes contact with the two electrodes 18' and 22' (short-circuiting them) and a pressure-dependent electrical contact is established between the two electrodes through the pressure-sensitive layer 30'.



Fig. 3 shows a block circuit diagram of an embodiment of a seat occupancy sensor. In this figure, the individual sensor cells 16 or 16' are drawn as variable resistances, because the electrical resistance of the foil-type pressure sensors reduces with increasing pressure on the cell.

In the embodiment shown, each of the switch elements 12 and 14 is composed of four individual sensor cells 16 or 16', all arranged in a row one behind the other. In this way, the individual cells of the switch element 12 or 14 are connected in parallel, so that for the sensor cells, each switch element implements a logical OR gate. As regards the switch elements 12 and 14, these are connected in series between two linking conductors 42 and 44 in series, so that the result is a logical AND gate (represented by the dash-dotted line 46).

Figure 4 shows a block circuit diagram of a further embodiment of a seat occupancy sensor according to the invention.

In a sitting surface 101 of a seat seen in plan view (not shown), two switch elements 102 and 103 are arranged, containing several sensor cells 102' and 103'. The cells 102' and 103' are drawn as variable resistances. These are foil-type pressure sensors, whose electrical resistance falls with increasing pressure exerted on the cell.

Looking in the direction of travel, the switch element 102 is on the left and the switch element 103 is on the right of the centreline 104 of the seat, also running in the direction of travel. As regards the switch elements 102' and 103', as in the embodiment described above, each of these is connected in parallel, so that for the sensor cells, each switch element implements a logical OR gate. As regards the switch elements 102 and 103, these are connected between two link connectors 105 and 106 in series, so that a logical AND gate results.

When a person sits on the seat, at least one of the sensor cells is pressed and its resistance is reduced to a value close to zero. As a consequence of this alteration in resistance, the total resistance of the AND gate constituted by the two switch elements 102 and 103 also falls to a value equal to or approaching zero.

This resistance value is typical for a seated person. In contrast, when an object is lying on the seat, the resistance value is as a rule significantly greater than zero, as the weight loading is asymmetrical and/or it is not so great as in the case of a person.

By this means, it is possible to recognize a person sitting on the seat with sufficient accuracy for applications that are not critical for safety.

***key to reference numbers***

	10	Seat occupancy sensor
	12	Switch element
5	14	Switch element
	16, 16'	Sensor cell
	18, 18'	Electrode
	20, 20'	Supporting foil
	22, 22'	Electrode
10	24, 24'	Supporting foil
	26, 26'	Recess
	28, 28'	Spacer
	30, 30'	Layer
	32, 34, 36, 38	Conductor track
15	40	Jumper
	42, 44	Linking conductor
	46	Representation of an AND gate